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Inhalant use and disorders among adults in the United States

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Abstract

Objective: To examine the patterns of adult inhalant use and correlates of inhalant use disorder.
Method: We drew study data from the 2002 and 2003 National Surveys on Drug Use and Health (NSDUH). We used logistic regression to identify the characteristics associated both with inhalant use and inhalant use disorder.
Results: One in 10 of all adults had used an inhalant at least once in their lives, and 0.5% used one in the past year. Among all past year inhalant users, 8% met the criteria for an inhalant use disorder (i.e., 6.6% for abuse and 1.1% for dependence) within that period. We found an increased prevalence of past year inhalant use among young adults aged 18–25 years, Asians, past year alcohol abusers and dependents, lifetime drug users, white women, and men reporting symptoms of serious mental illness. Inhalant-using adults who met the criteria for an inhalant use disorder were predominantly adults aged 35–49 years and were less educated, had received recent professional treatment for emotional or psychological problems, used inhalants weekly, and had a coexisting alcohol use disorder.
Conclusion: The patterns and consequences of adult inhalant use differ from those of adolescents. Compared with adolescent inhalant users, adult users tend not to initiate inhalant use until adulthood, use inhalants less frequently, use fewer inhalants, and are less likely to engage in criminal activities.

Keywords: Adults; Alcohol use disorders; Gender differences; Inhalant use; Inhalant use disorders

1. Introduction

Inhalant use is defined as the deliberate inhalation of volatile substances (e.g., glue, shoe polish, gasoline, paint, cleaning fluids, and amyl nitrite), either by sniffing, snorting, bagging, or huffing the substance, in order to induce a psychoactive or mind-altering effect (National Institute on Drug Abuse, 2000). Inhalant use-related problems affect youths worldwide, particularly socioeconomically disadvantaged children and adolescents (De Micheli and Formigoni, 2004; Kozel et al., 1995; Pagare et al., 2004; Tapia-Conyer et al., 1995). Second only to marijuana, inhalants constitute the illicit drug most likely to be used by American youths (Johnston et al., 2005).

Inhalant use is a serious public health concern and has several adverse medical consequences. It is associated with substantial cardiac, renal, hepatic, and neurological morbidity and mortality (American Academy of Pediatrics, 1996; Anderson and Loomis, 2003; Bowen et al., 1999). Inhalation of nitrites also impairs immune functioning that suppresses resistance to infection and actively promotes viral replication and tumor growth (Soderberg, 1998). Several studies have suggested that youthful inhalant use is highly associated with alcohol abuse or dependence, the use of multiple illicit drugs, and injection drug use (Bennett et al., 2000; Dinwiddie et al., 1991; Schütz et al., 1994; Wu et al., 2004, 2005a,b). Early inhalant use is also associated with later initiation of heroin and other opiates (Johnson et al., 1995; Storr et al., 2005). A recent study of a national sample of American adolescents aged 12–17 years found that 11% of past year inhalant users met the criteria for an inhalant use disorder in the past year (Wu et al., 2004).

Studies have also indicated that inhalant users tend to engage in antisocial or criminal activities and to experience symptoms of depression and various other psychological problems (Kelder et al., 2001; Mackesy-Amiti and Fendrich, 1999; Wu et al., 2004). In particular, investigators have found a strong association between inhalant use, antisocial personality, and criminal behaviors, and they have considered inhalant use by minors as one of many delinquent behaviors (Compton et al., 1994;

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Howard and Jenson, 1999; McGarvey et al., 1996; Mackesy-Amiti and Fendrich, 1999; Young et al., 1999). For instance, youths who are incarcerated in juvenile detention facilities tend to initiate inhalant use early and to use multiple drugs (McGarvey et al., 1996; Young et al., 1999).

Probably because inhalant use demonstrates a strong age-related pattern of decline and inhalants appear to be seen as "kids' drugs" (Johnston et al., 2005), studies of inhalant use have focused mainly on younger adolescents. With the exception of some studies of nitrite inhalant use among small population subgroups, such as drug users and men who have sex with men (Colfax et al., 2001; Israelstam et al., 1978; Lange et al., 1988; Seage et al., 1992), the patterns and correlates of recent or active inhalant use among adults have not received research attention. In particular, little is known about inhalant use patterns and disorders within the general adult population.

Descriptive findings of U.S. national surveys have suggested that nitrite inhalants (poppers) are the primary inhalants used by adults (Office of Applied Studies [OAS], 2000). Available studies of men who had sex with men have consistently found a significant association between nitrite inhalant use and risky sexual behaviors, drug use, and transmission of sexually transmitted diseases (STDs) (e.g., human immunodeficiency virus [HIV] infection) (Colfax et al., 2001; Robins et al., 1997; Seage et al., 1992; Woody et al., 1999). One recent study of adolescents in the general population reported that nitrite inhalant users tend to engage in delinquent activities and have co-occurring multiple drug abuse and mental health problems (Wu et al., 2005b). Studies of adolescents also have suggested some gender differences in the choice of inhalants used (Wu et al., 2004). Female adolescents tend to use glue/shoe polish, spray paints, and correction fluid, while male adolescents are more likely to use gasoline/lighter fluid and nitrous oxide (Wu et al., 2004). However, inhalant use among adult women has yet to be examined.

The purpose of this study is to describe inhalant use and disorders among adults and to compare the pattern of use with adolescent inhalant use. Our sample consists of respondents who participated in the 2002 or 2003 National Surveys on Drug Use and Health (NSDUH). Our study addresses the following questions: (1) What is the prevalence of adult inhalant use and inhalant use disorders? (2) Are there gender differences in the patterns and correlates of adult inhalant use? (3) Do the prevalence and patterns of inhalant use and disorders among adults differ from those that have been observed among adolescents? (4) How do the characteristics of the two groups of inhalant users differ in regard to substance use patterns, mental health problems, and criminal behavior?

2. Methods

2.1. Data source

This study used data available from the public use files of the 2002 and 2003 NSDUH, formerly known as the National Household Survey on Drug Abuse (NHSDA) (OAS, 2003, 2004). NSDUH is an annual national survey of the use of a variety of licit and illicit substances by Americans aged 12 years or older. This survey uses multistage area probability sampling methods (Bowman et al., 2003) to select survey respondents, including residents of noninstitutional group quarters (e.g., shelters, rooming houses, dormitories, and group homes), residents of all 50 states, and civilians residing on military bases. Individuals with no fixed household address at the time of the survey (e.g., homeless transients not in shelters) and residents of institutional group quarters (e.g., jails and hospitals) were excluded from the sampling frame.

Respondents were interviewed at their place of residence for about an hour. Interviewers requested respondents to identify a private area in their homes away from other household members in which to conduct the interview. The survey utilized a combination of computer-assisted personal interviewing (CAPI) and audio computer-assisted self-interviewing (ACASI) methodologies. ACASI was used for questions of a sensitive nature, such as substance use. Respondents either read the questions on the computer screen, or the questions were read to them through headphones. In either case, they entered their responses directly into a laptop computer.

A total of 68,126 and 67,784 individuals aged 12 years or older completed the 2002 and 2003 surveys, respectively. A weighted screening response rate of 91% was achieved in both years (OAS, 2003, 2004); the weighted interview response rates were 79% in 2002 and 77% in 2003. Analysis weights were developed to adjust for variation in household selection and nonresponse and included poststratification of the selected sample to U.S. census data to ensure that certain groups (e.g., different ages and ethnicities) would be adequately represented in the NSDUH sample in the same proportion as in the census. Each independent, cross-sectional NSDUH sample was considered representative of the U.S. general population aged 12 years or older. NSDUH design and data collection procedures have been reported in detail elsewhere (OAS, 2003, 2004).

2.2. Study sample

We studied adult respondents aged 18 years or older ($N = 36{,}370$ in 2002; $N = 37{,}026$ in 2003). We found no significant variation in the distribution of age, gender, race/ethnicity, educational level, family income, marital status, and population density across the two surveys. In the combined sample ($N = 73{,}396$), 52% were females, 31% were aged 18–34 years, 29% were members of nonwhite minority groups, 57% were currently married, 50% had not attended college, 45% reported an annual family income of US$ 40,000 or less, and 22% resided in nonmetropolitan areas.

2.3. Study variables

2.3.1. Inhalant and other substance use variables. Our primary outcomes of interest were lifetime and past year inhalant use and past year inhalant use disorders, related either to abuse or dependence (Wu et al., 2004, 2005a). In NSDUH, inhalant use is defined as any use of the following types of substances, as well as any other substances that people may have sniffed or inhaled "for kicks or to get high": (1) correction fluid, degreaser, or cleaning fluid; (2) gasoline or lighter fluid; (3) glue, shoe polish, or toluene; (4) ether, halothane, or other anesthetics; (5) lighter gases, butane, or propane; (6) nitrous oxide or whippets; (7) spray paints; (8) lacquer thinner and other paint solvents; (9) amyl nitrite, poppers, rush, or locker room deodorizers; and (10) aerosol sprays. An additional "other" encompasses all the other inhalants not specified in the above categories.

We grouped the different types of inhalants that respondents used into three categories: one, two, and three or more types (Wu et al., 2004). We then grouped respondents' age of first inhalant use into three categories, namely 14 years or younger, 15–17 years, and 18 years or older. We considered the use of inhalants on at least 1 day per week in the past year as weekly use (Wu et al., 2004). We determined past year inhalant use disorders related to abuse or dependence, as well as alcohol use disorders, by means of criteria specified in the fourth edition of the *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV) (American Psychiatric Association [APA], 1994). We considered inhalant abuse present when at least one of four DSM-IV inhalant abuse criteria was met in the past year, and when the criteria for inhalant dependence were not met. Inhalant dependence was present when respondents' level of inhalant use in the past year satisfied at least three DSM-IV inhalant dependence criteria (APA, 1994; Wu et al., 2004, 2005a). We referred the diagnosis of an inhalant

use disorder as abuse of or dependence on *any* inhalant because the NSDUH assessed DSM-IV criteria for any inhalant-related problem. Lifetime inhalant use disorders were not assessed by NSDUH.

We dichotomized past year DSM-IV alcohol use disorder as "yes" or "no." We summed the number of other drugs used (i.e., cocaine/crack, marijuana/hashish, heroin, hallucinogens, sedatives, tranquilizers, pain relievers, and stimulants) and grouped them into four categories (i.e., none, 1, 2, and 3 or more classes of drugs).

2.3.2. Social and demographic variables. We examined the following demographic characteristics in relation to inhalant use and disorders: age, gender, race/ethnicity, educational status (i.e., highest grade or years of school completed), marital status, total family income, and population density in the area where the respondent resided. We categorized race/ethnicity into six groups: non-Hispanic whites, African Americans, Hispanics, American Indians or Alaska Natives, Asians (including Pacific Islanders and Native Hawaiians), and more than one race. NSDUH classified population density as large metropolitan areas (with a population ≥1 million), small metropolitan areas (with a population <1 million), and non-metropolitan areas (outside of a metropolitan statistical area).

2.3.3. Mental health and criminality variables. We also examined the severity of serious mental illness (SMI), the use of mental health treatment services, and criminal activities as potential correlates of inhalant use. We assessed SMI by means of the K6 scale of nonspecific psychological distress (Kessler et al., 2002, 2003) The six questions in the K6 scale ask respondents how frequently they experienced symptoms of psychological distress during the 1 month in the past year when they experienced the most emotional distress. The K6 has strong psychometric properties and has demonstrated adequate sensitivity and specificity in discriminating DSM-IV cases (Andrews and Slade, 2001; Kessler et al., 2002). It also serves as a good screening scale in detecting DSM-IV mood and anxiety disorders and outperforms the General Health Questionnaire (Furukawa et al., 2003). Responses of the K6 are recorded on a five-category scale ranging from "all of the time" to "none of the time" and are coded as 4–0. The K6 is converted to a 0–24 scale by reverse coding responses to the questions and then summing the scores. Respondents in the general population who score at least 13 on the K6 are considered to have SMI (Kessler et al., 2003). Instead of treating it as a binary variable, we recoded the scores of SMI into four categories: 0–6, 7–12, 13–18, and 19–24 and examined it as an ordinal variable. We sought to determine whether a higher level of SMI would be more likely than a lower level to be associated with an inhalant use disorder.

Use of mental health treatment was defined as the receipt of treatment or counseling in the past year for any problems with emotions, "nerves," or mental health in any inpatient or outpatient setting, including the use of prescription medication for treatment of a mental or an emotional condition (OAS, 2004). We did not classify respondents as receiving mental health treatment who were treated for a substance use problem only. We classified respondents as engaging in criminal activities in the past year if they were booked or arrested for breaking the law, excluding minor traffic violations. NSDUH explicitly specifies "being booked" as being taken into custody and processed by the police or by someone connected with the courts, even if the respondent was later released.

2.4. Data analysis

To be representative of the noninstitutionalized, civilian population of Americans, we weighted and analyzed NSDUH data using SUDAAN® software (Research Triangle Institute, 2002), which applies a Taylor series linearization method to apply weights to compensate for the design effects of the complex NSDUH sampling strategy. All estimates that we report in this paper are weighted, while sample sizes are unweighted.

We examined the prevalence of lifetime and past year inhalant use, as well as past year inhalant use disorder, among all adult respondents. Among the subsample of inhalant users, we then determined patterns of inhalant use behaviors and estimated the prevalence of inhalant use disorders. We conducted gender-specific regression procedures to identify the characteristics associated with inhalant use and inhalant use disorder, separately. We report odds ratios (ORs) as the index of the strength of the associations noted.

3. Results

3.1. Characteristics of lifetime inhalant users

Among adults aged 18 years or older ($N = 73{,}396$), 9.7% reported any lifetime use of inhalants. This figure represents approximately 20.5 million adults. We found no significant yearly differences in the prevalence of lifetime inhalant use across our 2 sampled years (9.6% in 2002 and 9.8% in 2003). As displayed in Table 1, lifetime inhalant users were very unlikely to be adults aged 50 years or older, but were more likely than nonusers to be male, white, American Indian or Alaska Native, or of multiethnic origin. They also tended to have never been married, to have attended college, to have a higher level of family income, and to reside in metropolitan areas.

Lifetime inhalant use was significantly associated with the severity of SMI, past year use of mental health treatment, past year criminal activity, past year alcohol use disorder, and lifetime use of multiple drugs. For example, more than 18% of adults with SMI reported lifetime inhalant use, as compared with 8% of those who were in lowest level of the SMI index. We observed a very high prevalence (29%) of lifetime inhalant use among adults who reported an alcohol use disorder in the past year. There was a positive, dose-related association between the number of other drugs that respondents used and lifetime inhalant use. One-half of adults who used at least four other classes of drugs had ever used inhalants compared with only 1% of those who had not used other drugs.

These characteristics of lifetime inhalant users were generally supported by multiple logistic regression procedures that held constant our adult sample's sociodemographic characteristics and mental health and substance use variables, as displayed in Table 2. However, past year criminal activity was not associated with lifetime inhalant use in this adjusted analysis. We found slight differences in the results of gender-specific logistic regression models for lifetime inhalant use. Women in the highest level of family income and who resided in small metropolitan areas were slightly more likely to have ever used an inhalant than women in the lowest level of family income and residents of non-metropolitan areas. These differences were not apparent among men.

3.2. Characteristics of past year inhalant users

Less than 1% of adults used inhalants in the past year (0.5% in 2002 and 0.4% in 2003). Although the characteristics of past year inhalant users were generally similar to those of lifetime users, there were some exceptions involving race/ethnicity and family income. We observed an increased prevalence of past year inhalant use among Asians (0.9%) and adults in the lowest level of family income (0.8%). Past year inhalant use also was associated with respondents aged 18–25 years (2.1%), past year criminal activity (2.3%), past year alcohol use disorders (2.5%), recent SMI (1.5%), and the use of at least three other types of drugs (1.1%).

The gender-specific adjusted logistic regression model confirmed elevated odds of recent (past year) inhalant use among

Table 1
Prevalence and crude odds ratio (OR) of inhalant use among adults aged 18 years or older ($N = 73,396$)

Variables	Overall	Lifetime inhalant use		Past year inhalant use	
Prevalence	Column %	Row %	Crude OR (95% CI)	Row %	Crude OR (95% CI)
Age group					
18–25	14.8	15.3	1.0	2.1	1.0
26–34	16.6	14.0	**0.9 (0.8–1.0) b**	0.3	**0.1 (0.09–0.2) c**
35–49	30.7	13.0	**0.8 (0.7–0.9) c**	0.3	**0.1 (0.08–0.2) c**
50 or older	37.9	2.9	**0.2 (0.1–0.2) c**	0.04	**0.02 (0.01–0.07) c**
Gender					
Female	52.0	6.3	1.0	0.3	1.0
Male	48.0	13.4	**2.3 (2.2–2.5) c**	0.7	**2.3 (2.1–2.5) c**
Race/ethnicity					
Non-Hispanic African American	11.1	3.5	1.0	0.2	1.0
Non-Hispanic white	71.0	11.5	**3.6 (3.0–4.4) c**	0.5	**2.9 (1.4–5.9) b**
Hispanic	12.1	6.1	**1.8 (1.4–2.3) c**	0.4	2.2 (1.0–5.2)
American Indian or Alaska Native	0.6	12.9	**4.1 (2.8–5.9) c**	0.3	1.9 (0.6–6.1)
Asian, Pacific Islander, Native Hawaiian	4.3	4.5	1.3 (0.9–1.9)	0.9	**5.1 (1.9–13.5) c**
More than one race	1.0	11.4	**3.6 (2.6–4.9) c**	0.7	**3.9 (1.6–9.4) b**
Educational level					
Less than high school	17.8	7.3	**0.6 (0.5–0.7) c**	0.6	1.3 (1.0–1.8)
High school	31.9	8.7	**0.8 (0.7–0.8) c**	0.4	0.9 (0.7–1.2)
College or more	50.3	11.2	1.0	0.5	1.0
Family income					
US$ 0–US$ 19,999	19.7	8.7	1.0	0.8	1.0
US$ 20,000–US$ 39,999	25.6	8.8	1.0 (0.9–1.1)	0.4	**0.5 (0.4–0.7) c**
US$ 40,000–US$ 74,999	30.9	9.8	**1.2 (1.0–1.3) b**	0.4	**0.5 (0.4–0.7) c**
US$ >75,000	23.9	11.3	**1.3 (1.2–1.5) c**	0.4	**0.5 (0.4–0.7) c**
Marital status					
Married	56.5	7.6	1.0	0.1	1.0
Widowed/divorced	19.7	7.6	1.0 (0.9–1.1)	0.1	0.7 (0.4–1.5)
Single	23.8	16.4	**2.4 (2.2–2.6) c**	1.6	**12.9 (8.6–19.4) c**
Population density					
Nonmetro areas	21.9	7.8	1.0	0.3	1.0
Small metro areas	33.2	10.0	**1.3 (1.2–1.5) c**	0.6	**1.7 (1.3–2.3) c**
Large metro areas	44.9	10.3	**1.4 (1.2–1.5) c**	0.5	**1.5 (1.1–2.0) c**
Past year mental health treatment					
No	86.9	8.7	1.0	0.4	1.0
Yes	13.1	16.3	**2.0 (1.9–2.2) c**	0.7	**1.8 (1.3–2.3) c**
Booked or arrested in the past year					
None	97.4	9.3	1.0	0.4	1.0
Once	2.0	24.1	**3.1 (2.7–3.6) c**	2.3	**5.7 (4.2–7.7) c**
More than once	0.6	25.8	**3.4 (2.6–4.4) c**	2.2	**5.4 (3.6–8.2) c**
Scores of serious mental illness					
0–6	74.3	7.6	1.0	0.3	1.0
7–12	17.1	14.3	**2.0 (1.9–2.2) c**	0.8	**2.0 (1.9–2.2) c**
13–18	6.8	18.6	**2.8 (2.5–3.1) c**	1.0	**2.8 (2.5–3.1) c**
19–24	1.9	18.1	**2.7 (2.2–3.2) c**	1.5	**2.7 (2.2–3.2) c**
Past year alcohol use disorder					
No	92.2	8.1	1.0	0.4	1.0
Yes	7.8	28.9	**4.6 (4.3–5.1) c**	2.5	**8.7 (6.9–11.0) c**
Number of other drug classes used					
None	52.4	1.0	1.0	0.1	1.0
1 drug	21.8	5.6	**5.6 (4.7–6.7) c**	0.4	**6.1 (3.3–11.2) c**
2 drugs	9.5	12.6	**13.7 (11.5–16.3) c**	0.5	**8.6 (4.9–15.2) c**
3 drugs	6.1	26.4	**34.2 (28.9–40.5) c**	1.1	**18.9 (10.6–33.6) c**
≥4 drugs	10.3	49.8	**94.6 (80.9–110.6) c**	1.1	**39.8 (24.0–65.8) c**

95% CI = 95% confidence interval. a, $p \leq 0.05$; b, $p \leq 0.01$; c, $p \leq 0.001$.

Table 2
Adjusted odds ratios (AOR) and 95% confidence intervals (CI) of lifetime and past year inhalant use among adults aged 18 years or older ($N = 73,396$)

Gender-specific adjusted logistic regression model	Lifetime inhalant use AOR (95% CI)		Past year inhalant use AOR (95% CI)	
	Men ($N = 34,292$)	Women ($N = 39,104$)	Men ($N = 34,292$)	Women ($N = 39,104$)
Age group (Ref = 18–25)				
26–34	**1.2 (1.0–1.4) a**	1.0 (0.8–1.2)	**0.2 (0.1–0.4) c**	**0.3 (0.1–0.7) b**
35–49	1.0 (0.8–1.1)	**0.6 (0.5–0.7) c**	**0.4 (0.3–0.8) b**	**0.1 (0.04–0.3) c**
50 or older	**0.5 (0.4–0.6) c**	**0.3 (0.2–0.4) c**	0.2 (0.03–1.3)	**0.04 (0.001–0.3) b**
Race/ethnicity (Ref = African American)				
White	**2.9 (2.2–3.9) c**	**2.7 (2.0–3.6) c**	2.3 (0.9–5.6)	**2.6 (1.3–5.2) b**
Hispanic	**1.7 (1.3–2.4) c**	**1.9 (1.4–2.7) c**	1.9 (0.7–5.3)	1.5 (0.6–3.5)
American Indian, Alaska Native	**2.3 (1.3–4.1) b**	**3.4 (2.0–5.6) c**	1.5 (0.4–6.2)	0.5 (0.1–3.1)
Asian, Pacific Islander, Native Hawaiian	**2.3 (1.2–4.1) b**	1.6 (0.9–2.8)	**5.5 (1.4–21.5) a**	**10.0 (2.8–35.7) c**
More than one race	**2.0 (1.3–3.2) b**	**1.7 (1.1–2.7) a**	2.1 (0.7–6.4)	2.5 (0.7–8.2)
Educational level (Ref ≥ college)				
<High school	**0.8 (0.7–0.9) b**	**0.7 (0.5–0.8) c**	1.2(0.8–1.8)	1.4 (0.7–2.5)
High school	**0.8 (0.7–0.9) c**	**0.7 (0.6–0.8) c**	0.9 (0.7–1.1)	1.1 (0.8–1.7)
Family income (Ref ≤ US$ 20 K)				
US$ 20 K–US$ 39,999	1.1 (0.9–1.2)	1.1 (0.9–1.3)	0.7 (0.5–1.0)	0.8 (0.5–1.4)
US$ 40 K–US$ 74,999	1.0 (0.9–1.2)	1.1 (0.9–1.3)	0.9 (0.6–1.3)	0.9 (0.6–1.5)
US$ ≥75 K	1.0 (0.9–1.2)	**1.3 (1.0–1.5) a**	0.8 (0.5–1.3)	1.0 (0.5–1.9)
Marital status (Ref = married)				
Widowed/divorced	1.0 (0.9–1.2)	0.9 (0.7–1.1)	0.7 (0.3–2.0)	0.6 (0.2–1.7)
Single	**1.4 (1.2–1.7) c**	**1.3 (1.1–1.5) b**	**4.7 (2.1–10.6) c**	1.5 (0.8–2.8)
Population density, areas (Ref = nonmetro)				
Large metro	1.1 (0.9–1.3)	1.2 (1.0–1.4)	1.4 (1.0–2.0)	1.1 (0.7–1.7)
Small metro	1.0 (0.9–1.1)	**1.2 (1.1–1.4) b**	**1.5 (1.0–2.1) a**	1.1 (0.7–1.8)
Past year mental health treatment (Ref = no)				
Yes	**1.3 (1.1–1.5) b**	**1.2 (1.1–1.4) b**	1.4 (0.9–2.1)	1.0 (0.7–1.5)
Booked or arrested in the past year (Ref = no)				
Once	0.9 (0.7–1.1)	1.1 (0.8–1.7)	1.1 (0.8–1.6)	1.1 (0.6–2.1)
More than once	0.8 (0.6–1.1)	1.3 (0.8–2.3)	0.8 (0.5–1.3)	1.0 (0.4–2.3)
Scores of serious mental illness (Ref = 0–6)				
7–12	**1.5 (1.3–1.7) c**	**1.3 (1.1–1.5) c**	**1.7 (1.1–2.5) a**	1.5 (0.82.7
13–18	**1.4 (1.1–1.7) b**	**1.4 (1.1–1.6) c**	1.2 (0.7–1.8)	1.5 (0.9–2.5)
19–24	1.2 (0.8–1.9)	1.3 (1.0–1.7)	**2.4 (1.1–5.7) a**	1.7 (0.9–2.4
Past year alcohol use disorder (Ref = no)				
Yes	**1.3 (1.2–1.5) c**	**1.3 (1.1–1.5) b**	**1.6 (1.2–2.1) b**	**2.8 (1.9–4.2) c**
Number of other drug classes used (Ref = none)				
1 drug	**3.7 (3.0–4.7) c**	**4.8 (3.6–6.3) c**	**5.5 (2.6–11.8) c**	2.0 (0.8–5.3
2 drugs	**8.7 (6.9–10.9) c**	**10.3 (7.7–13.8) c**	**5.1 (2.7–9.5) c**	**4.5 (1.6–12.5) c**
3 drugs	**19.6 (15.4–24.7) c**	**26.4 (20.0–35.0) c**	**12.3 (6.5–23.0) c**	**5.7 (2.1–15.2) c**
≥4 drugs	**50.6 (41.0–62.5) c**	**66.1 (50.6–86.4) c**	**17.7 (10.0–31.3) c**	**15.8 (6.6–38.1) c**
Survey year (Ref = 2002)				
2003	1.0 (0.9–1.1)	1.0 (0.9–1.1)	0.8 (0.6–1.1)	1.2 (0.8–1.7)

Ref, reference group; a, $p \leq 0.05$; b, $p \leq 0.01$; c, $p \leq 0.001$.

Asian men and women, and it also showed some variations in the past year inhalant use. Never having been married and symptoms of SMI were associated with recent inhalant use among men, but not among women. Family income was unassociated with recent inhalant use once we controlled for respondents' sociodemographic characteristics, mental health variables, and other substance use variables. Regardless of gender, there was a strong association between past year inhalant use and the number of other drugs that respondents used.

Gender differences in inhalant use were found by the adjusted logistic regression model that controlled for all the variables listed in Table 2. Men were twice as likely as women to report both lifetime (adjusted OR [AOR] = 2.2; 95% confidence interval [CI] = 2.0–2.4) and past year (AOR = 1.8; 95% CI = 1.4–2.3) inhalant use.

3.3. Patterns of inhalant use

3.3.1. Lifetime use patterns. As displayed in Table 3, the most commonly used inhalants by adults were nitrous oxide (whippets) and amyl nitrite (poppers or rush), which were reported by 55% and 42% of lifetime inhalant users, respectively. We

Table 3
Prevalence of inhalant use by type of inhalants used and pattern of inhalant use among adult inhalant users aged 18 years or older ($N = 9671$)

Type of inhalants used	Lifetime inhalant use (%)			Past year inhalant use (%)		
	Total $N = 9671$	Men $N = 5982$	Women $N = 3689$	Total $N = 863$	Men $N = 579$	Women $N = 284$
Nitrous oxide, whippets	55.0	56.0	53.0	68.1	**64.4**	**76.2 a**
Amyl nitrite, poppers, rush	41.6	41.6	41.5	32.4	34.7	27.4
Glue, shoe polish, toluene	16.1	**17.2**	**13.9 b**	14.6	14.8	14.7
Gasoline, lighter fluid	15.1	**17.1**	**11.1 c**	14.8	16.2	11.8
Correction fluid, degreaser	8.3	8.0	8.7	12.3	10.8	15.8
Paint solvents, lacquer thinner	7.8	**9.2**	**5.0 c**	12.7	13.9	10.2
Aerosol sprays	7.7	7.7	7.8	14.7	14.8	14.7
Spray paints	6.5	6.9	5.7	10.8	10.9	10.7
Ether, halothane, anesthetic	5.4	5.8	4.6	6.8	**8.2**	**3.8 a**
Lighter gases, butane, propane	3.5	**3.9**	**2.7 a**	8.7	9.2	7.4
Other inhalants	4.3	4.7	3.6	5.1	5.8	3.7
Number of different types of inhalants used[a]						
1	61.9	**60.3**	**65.0 c**	55.6	54.2	58.7
2	22.6	**22.6**	**22.6**	22.5	22.7	22.0
3 or more inhalants	15.5	**17.1**	**12.4**	22.0	23.2	19.2
Age of first inhalant use, years						
14 or younger	21.5	21.0	22.4	11.9	11.3	13.2
15–17	34.3	34.1	34.7	28.8	25.9	34.8
18 or older	44.2	44.9	43.0	59.4	62.8	52.0
Past year number of days using inhalants						
None	95.2	95.1	95.5	–	–	–
1	1.3	1.1	1.6	26.3	**21.8**	**35.9 a**
2–5	1.6	1.7	1.6	34.4	**34.1**	**35.1**
6 or more days	1.9	2.2	1.3	39.3	**44.0**	**29.0**
Past year weekly inhalant use	0.6	**0.7**	**0.2 a**	11.5	**14.3**	**5.4 a**

All prevalence estimates are weighted figures. Chi square tests for each inhalant variable and gender: a, $p \leq 0.05$; b, $p \leq 0.01$; c, $p \leq 0.001$.
[a] A total of two cases of inhalant users did not report type of inhalants used.

also found gender differences in the types of inhalants used. Compared with lifetime female inhalant users, lifetime male users were more likely to have ever used glue or shoe polish (17% versus 14%); gasoline or lighter fluid (17% versus 11%); paint solvents or lacquer thinner (9% versus 5%); lighter gases, butane, or propane (4% versus 3%); and two or more inhalants (40% versus 35%) and to use inhalants on a weekly basis over the past year (0.7% versus 0.2%). There were no gender differences in the age of first inhalant use. Approximately 44% of lifetime inhalant users reported initiating inhalant use at age 18 years or older.

3.3.2. Past year use patterns. Approximately 5% of all lifetime inhalant users used inhalants in the past year, representing approximately 1 million adults. Among all past year inhalant users, 68% used nitrous oxide (whippets) and 32% used amyl nitrite (poppers or rush). Relative to the pattern of inhalant use among lifetime users, past year inhalant-using women were more likely than inhalant-using men to use nitrous oxide (whippets) (76% versus 64%), but were less likely than men to use ether (anesthetics) (4% versus 8%). The vast majority of past year inhalant users reported using inhalants on more than 1 day, and men were more likely than women to do so (78% versus 64%). Almost 12% of past year inhalant users used inhalants at least weekly, and men were more likely than women to do so (14% versus 5%). An estimated 44% of past year inhalant users used two or more inhalants in the past year, and the majority (59%) of users initiated inhalant use at age 18 years or older.

3.4. Prevalence of inhalant use disorder

Among all adults aged 18 years or older ($N = 73{,}396$), 0.04% ($n = 45$) met the criteria for inhalant abuse (0.03%) or dependence (0.01%) in the past year. Among the subsample of past year inhalant users ($N = 863$), 7.7% ($n = 45$) met the criteria for past year inhalant abuse (6.6%) or dependence (1.1%). There were no significant gender differences in inhalant abuse or dependence among past year inhalant users: 9% of men (abuse, 7.2%; dependence, 1.4%) and 6% of women (abuse, 5.2%; dependence, 0.5%) met the criteria for an inhalant use disorder.

Notably, we found a high prevalence of inhalant use disorders among several subgroups of past year inhalant users, including adults aged 35–49 years (25%), those who did not complete high school (20%) or who received mental health treatment in the past year (23%), and weekly inhalant users (33%). Gender-specific unadjusted logistic regression analyses revealed some interesting variations in the prevalence of inhalant use disorders among past year inhalant users (Table 4). To help describe the

Table 4
Crude odds ratios (ORs), adjusted odds ratios (AORs), and 95% confidence intervals (CIs) of past year inhalant use disorder among past year adult inhalant users ($N = 863$)

Logistic regression model	Men ($N = 579$) Crude OR (95% CI)	Women ($N = 284$) Crude OR (95% CI)	Overall ($N = 821$)[a] AOR (95% CI)
Gender (Ref = female)			
Male	–	–	1.0 (0.3–4.0)
Age group[b] (Ref = 18–25)			
26–34	–	–	–
35–49	**5.5 (1.8–17.2) b**	**12.4 (1.2–134.9) a**	**5.3 (1.5–19.1) b**
50 or older	–	–	–
Race/ethnicity (Ref = African American)			
White	**0.1 (0.01–0.6) a**	1.3 (0.1–14.6)[c]	0.3 (0.1–1.2)
Asian	0.2 (0.01–3.7)	**21.7 (1.2–404.4) a**[c]	3.0 (0.5–17.5)
Other	**0.1 (0.01–0.9) a**	0.3 (0.01–4.8)[c]	0.4 (0.1–2.0)
Educational level (Ref ≥ college)			
<High school	**18.4 (3.4–99.2) c**	4.4 (0.5–38.5)	**12.4 (4.4–34.9) c**
High school	**7.2 (1.4–36.3) b**	–	**3.8 (1.2–12.5) a**
Family income (Ref ≤ US$ 20 K)			
US$ 20,000–US$ 39,999	1.5 (0.4–6.7)	0.4 (0.1–3.1)	1.0 (0.4–2.7)
US$ 40,000–US$ 74,999	**0.2 (0.1–0.9) a**	4.5 (0.5–40.2)	**0.2 (0.1–0.9) a**
US$ ≥75,000	0.4 (0.1–1.6)	3.0 (0.4–24.1)	1.2 (0.2–7.1)
Marital status (Ref = married)			
Widowed or divorced	**14.2 (1.2–163.0) a**	–	2.2 (0.3–17.0)
Single	0.9 (0.1–5.9)	0.2 (0.02–1.9)	1.7 (0.4–7.3)
Population density, areas (Ref = nonmetro)			
Large metro	0.3 (0.1–1.3)	2.9 (0.3–27.0)	0.7 (0.3–2.1)
Small metro	0.4 (0.1–2.1)	1.9 (0.3–12.4)	1.0 (0.3–3.2)
Past year mental health treatment (Ref = no)			
Yes	**21.2 (8.2–54.8) c**	1.0 (0.1–8.8)	**4.3 (1.5–12.9) b**
Booked or arrested in the past year (Ref = no)			
Once	1.8 (0.4–7.4)	0.1 (0.02–1.3)	–
More than once	0.2 (0.03–1.8)	–	–
Scores of serious mental illness (Ref = 0–6)			
7–12	**4.0 (1.0–15.2) a**	2.7 (0.3–24.1)	3.3 (0.6–17.8)
13–18	3.4 (0.7–15.4)	–	0.8 (0.1–5.3)
19–24	**46.0 (6.7–316.1) c**	0.4 (0.03–5.4)	3.0 (0.6–17.0)
Past year alcohol use disorder (Ref = no)			
Yes	1.7 (0.5–5.8)	1.0 (0.1–8.0)	**7.6 (2.6–21.8) c**
Number of other drug classes used (Ref = no)			
1 drug	6.7 (0.7–66.8)	–	0.9 (0.1–6.3)
2 drugs	2.3 (0.3–18.3)	–	0.3 (0.04–2.2)
3 drugs	**15.7 (1.6–150.2) a**	–	0.5 (0.08–3.1)
≥4 drugs	5.9 (0.9–37.6)	–	0.7 (0.1–3.6)
Past year weekly inhalant use (Ref = no)			
Yes	**7.3 (2.0–27.6) b**	**47.0 (4.7–475.2) c**	**3.7 (1.5–9.6) b**
Age of first inhalant use, years (Ref ≥ 18)			
≤14	2.7 (0.8–8.7)	8.2 (0.9–72.2)	2.2 (0.7–6.8)
15–17	1.6 (0.3–8.4)	–	0.5 (0.2–1.2)
Number of different types of inhalants used (Ref = 1)			
2	**8.8 (2.0–38.4) a**	0.2 (0.03–1.4)	1.7 (0.6–5.1)
3 or more inhalants	**9.9 (3.7–26.6) c**	–	2.0 (0.7–6.0)

Ref, reference group; a, $p \leq 0.05$; b, $p \leq 0.01$; c, $p \leq 0.001$.

[a] Because all cases of inhalant use disorders were concentrated in those aged 18–25 years and those aged 35–49 years, the analysis of the adjusted model was based on these two age groups only ($N = 821$). A total of 42 cases of past year inhalant users in the other age groups were excluded from the analysis.

[b] There were no cases of inhalant use disorders among those aged 26–34 years and among those aged 50 years or older.

[c] Among female past year inhalant users, the weighted prevalence of inhalant use disorders was 3% ($n = 5$) among whites; 2% ($n = 1$) among African Americans; 32% ($n = 3$) among Asians, Pacific Islanders, or Native Hawaiians; 0.7% ($n = 1$) among Hispanics; 0% among American Indians, Alaska Natives, and those who reported more than one race.

distribution of the inhalant use disorder by gender, we reported the prevalence of inhalant use disorder among subgroups of past year inhalant users that were suggested by unadjusted logistic regression analyses to have a higher prevalence of the disorders than the other subgroups. Among past year inhalant-using men ($N = 579$), an increased prevalence of inhalant use disorder was observed among adults aged 35–49 years (24%), African Americans (44%), those who did not complete high school (21%), divorced or widowed men (54%), those who had a family income lower than US$ 40,000 (11–16%), past year users of mental health treatment (37%), multidrug users (18%), weekly inhalant users (29%), and multiple inhalant users (16%). Among past year inhalant-using women ($N = 284$), an increased prevalence of inhalant use disorder was found among women who were aged 35–49 years (32%), Asians (32%), and those using inhalants weekly (57%).

3.5. Correlates of inhalant use disorder

Because all cases of past year inhalant use disorder were limited to adults in the age ranges of 18–25 and 35–49 years, we conducted multiple logistic regression procedures to examine the correlates of inhalant use disorder among adults in these two age groups and who used inhalants in the past year ($N = 821$). After controlling for sociodemographic variables and mental health and substance use characteristics, past year inhalant users aged 35–49 years were five times as likely as those aged 18–25 years to have met the criteria for inhalant use disorders (Table 4). Increased odds of inhalant use disorders also were observed among inhalant users who lacked a college education and who reported the lowest level of family income. Adult inhalant users who did not complete high school were 12 times as likely as users who attended college to meet the criteria for inhalant use disorders. Compared with inhalant users who did not meet the criteria for inhalant use disorders, those who met these criteria were about four times as likely to receive treatment for mental health problems in the past year, eight times as likely to have a past year alcohol use disorder, and four times as likely to use inhalants weekly.

4. Discussion

Our study's primary goals were to estimate and determine the correlates of inhalant use and inhalant use disorders in a nationally representative sample of adults. We found that approximately 1 in 10 adults had ever used an inhalant, and 0.5% had used it in the past year. We also found that 0.04% of adults met the criteria for past year inhalant use disorders. Among adults who used inhalants in the past year, 8% met the criteria for an inhalant use disorder. To the best of our knowledge, this study is the first to examine the pattern of inhalant use and correlates of past year inhalant use disorders among adults within the general population.

Recent national surveys of American youths have found that, although most categories of drug use have declined, inhalant use appears to have been increasing (Johnston et al., 2005). The prevalence estimates of lifetime inhalant use (10%) in our study appear to be slightly higher than the estimate derived from the 1990–1992 National Comorbidity Survey (NCS), which reported a lifetime prevalence of 7% among all respondents aged 15–54 years. Our prevalence estimate of lifetime inhalant use, however, is congruent with reports from the monitoring the future (MTF) school-based survey (Johnston et al., 2004). In our sample of young adults aged 18–25 years, 15% reported lifetime inhalant use and 2% used it in the past year. Corresponding prevalence estimates among college students in the 2002–2003 MTF were 8–10% and 2%, respectively (Johnston et al., 2004). The NSDUH sampling frame includes school dropouts who tend to have a higher prevalence of inhalant use than non-dropouts (Bates et al., 1997).

In the NCS, 0.3% of all respondents aged 15–54 years, or 4% of all lifetime inhalant users, met DSM-III-R criteria for lifetime inhalant dependence (Anthony et al., 1994). In our study, past year prevalence estimates of DSM-IV inhalant abuse and dependence among past year inhalant users were 6.6% and 1.1%, respectively. The 2001–2002 National Epidemiologic Survey on Alcohol and Related Conditions (NESARC) reported that 0.02% of adults aged 18 years or older met the criteria for past year DSM-IV inhalant abuse (Grant et al., 2004), an estimate that is very close the our finding of 0.03% for inhalant abuse. The MTF does not assess inhalant use disorders. Relative to the prevalence of lifetime inhalant use, we found that past year inhalant use disorders were rare.

Contrary to adolescent inhalant users who are most likely to sniff glue, shoe polish, and gasoline (Wu et al., 2004), we found that nitrous oxide (whippets) and amyl nitrite (poppers or rush) were the inhalants of choice among adults. Relevant to the findings from our earlier study of adolescent inhalant users aged 12–17 years (Wu et al., 2004), we found in this study that past year adult inhalant users were *less* likely than past year adolescent users to use multiple types of inhalants (45% versus 60%) and to use inhalants weekly or more (12% versus 20%). Although about 80% of lifetime adolescent inhalant users initiated use before age 15 years (Wu et al., 2004), only 22% of lifetime adult users in this study did so. Our findings indicate that the majority (59%) of past year adult inhalant users initiated such use as adults, suggesting that the profile of adult inhalant users is distinct from the profile for adolescent users.

Our prevalence estimate of overall inhalant use disorders among past year adult inhalant users (7.7%) is slightly lower than our previously reported estimate (10.9%) of similar disorders among adolescent inhalant users aged 12–17 years (Wu et al., 2004). Our findings also suggest that past year *adolescent* inhalant users are more likely than past year *adult* inhalant users to depend on inhalants. In our adult sample, only 1.1% of the 7.7% inhalant use disorders was considered dependence, compared with 4.3% of the 10.9% among adolescent inhalant users (Wu et al., 2004). This finding may be explained by a lower prevalence of multiple and regular inhalant use among adult than adolescent inhalant users. We suspect that adults and adolescents use inhalants for different reasons. More studies would be needed to clarify the differential reasons and contexts for inhalant use by adults and adolescents.

Although the prevalence of recent inhalant use disorders among all adults was very low, its relatively high prevalence among several subgroups of inhalant users is noteworthy. Logistic regression analyses that held constant the respondents' sociodemographic characteristics, mental health variables, and other substance use variables suggested that past year inhalant users who met the criteria for a past year inhalant use disorder were likely to be aged 35–49 years, to have not attended college, to have received mental health treatment recently, to abuse alcohol, and to use inhalants at least once a week. Additionally, we found that the choice of inhalants used was somewhat related to gender: women were more likely than men to use nitrous oxide, but were less likely to use anesthetics.

Our findings also suggest that men were more likely than women to use inhalants and to use them weekly. Prior studies of adolescents aged 12–17 years who participated in the 1990–1995 and 2000–2001 NHSDA surveys did not found gender differences in lifetime inhalant use (Neumark et al., 1998; Wu et al., 2004). This discrepancy is probably associated with age-related gender differences in inhalant use: that is, younger females may be more likely than older females to use inhalants. Alternatively, adults in this study may have underreported inhalant use, and women may be more likely than men to do so. Similar to the pattern of lifetime inhalant use among adolescent (Johnston et al., 2005), we found that the prevalence of lifetime inhalant use did not increased with older age strata, and that adults aged 50 years or older had a very low prevalence of lifetime inhalant use (3%). When we further categorized those aged 50 years or older into two groups: 50–64 and 65 years or older, we found that the prevalence of lifetime inhalant use was only 0.9% among the latter group, in contrast to 4.4% among those aged 50–64 years. The low prevalence of inhalant use among adults, particularly the older adults, may be due to both forgetting and underreporting. The latter may be explained partly by denial, embarrassment, and stigma because inhalants tend to be considered a "kid's drug." Women, and particularly older women, could deny such use because of the greater social stigma and disapproval associated with their (as opposed to men's) inhalant use. This hypothesis, however, is speculative and needs support from future studies of the validity of self-reported inhalant use among adults.

Previous studies of adolescents have found that inhalant use is frequently associated with delinquent or criminal activities (Howard and Jenson, 1999; Mackesy-Amiti and Fendrich, 1999; McGarvey et al., 1996; Wu et al., 2004; Young et al., 1999) and suggest that inhalant use may be more closely associated with delinquency than the use of other drugs (Mackesy-Amiti and Fendrich, 1999). In this adult sample, past year criminal activity was associated with inhalant use in our bivariate analyses only, and it was not common among past year inhalant users who had a inhalant use disorder. We also found that adults with at least some college education reported the highest prevalence of lifetime inhalant use, although they were least likely to meet the criteria for an inhalant use disorder given their past year inhalant use. These finding suggest that although adults with at least some college education are more likely than those who did not attend college to try inhalants for experimental use, they appear to have a very low probability of using the substance regularly.

The association between inhalant use disorders and race/ethnicity also deserves mention. Among youths, African Americans are the least likely to use inhalants, while whites tend to have the highest prevalence of such use, with the exception of American Indians (Beauvais et al., 2002; Mackesy-Amiti and Fendrich, 2000; McGarvey et al., 1999; Neumark et al., 1998). National surveys of Americans also have found a very low prevalence of drug use among Asians (OAS, 2004). Unexpectedly, our findings suggest that Asian adults may be at greater risk for recent inhalant use than generally thought. In our study, both Asian men and women, similar to white women, had increased odds of past year inhalant use. Among past year inhalant users, we observed a surprisingly high prevalence of inhalant use disorders among Asian women, as well as among African American men. Perhaps the licit nature of commercial products, and their ready availability, may make them more attractive to Asians than other racial/ethnic groups, given the risks that this group may perceive associated with drugs obtained through illicit channels, because of their stigma or cultural prohibition. Given the small sample of past year inhalant users who were Asians, however, our findings should be considered preliminary.

We note several limitations to the methodology of this study. First, our findings are based on self-reports by adults, which are subject to various recall and reporting biases. Recall biases may have a stronger influence on inhalant use that our adult respondents initiated during childhood or adolescence than those that were initiated after they turned 18. It is also entirely possible that respondents generally underreported their use of inhalants and other drugs (Gfroerer et al., 1997). Nonetheless, the NHSDA–NSDUH data collection strategy is known to produce more valid reports of drug use than telephone surveys (Turner et al., 1992). Second, very high-risk groups, such as adults who were incarcerated, homeless, or institutionalized at the time of the survey, were not included in NSDUH. Hence, we may have underestimated the prevalence of inhalant use and its related disorder. Further, the cross-sectional nature of the NSDUH design precludes interpreting any associations as causal in nature.

Compared with adolescent inhalant users, adult users tend to initiate inhalant use during adulthood, use different and fewer inhalants, use them less frequently, and are less likely to engage in criminal activities. Adult inhalant users are thus different from those who used inhalants as adolescents, and findings from studies of adolescent inhalant use cannot be completely generalized to adults. Inhalant-using adults who met the criteria for an inhalant use disorder were predominantly aged 35–49 years, less educated, receiving professional treatment for emotional or psychological problems, and characterized by a coexisting alcohol use disorder. Inhalant users are at risk for serious pulmonary, cardiac, hematological, and hepatic toxicity, including life-threatening respiratory depression and arrhythmias (Kolecki and Shih, 2004). The most commonly used inhalants, nitrites and nitrous oxide, may cause peripheral neuropathy and hematological abnormalities (Kolecki and Shih, 2004). Our study findings

identify several population subgroups that warrant further investigations of inhalant use and abuse among adults.

Human participant protection

This study was declared exempt from the RTI International institutional review board because it used an existing public use data file. No information or identifiers on the data file can be associated with any survey respondent.

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